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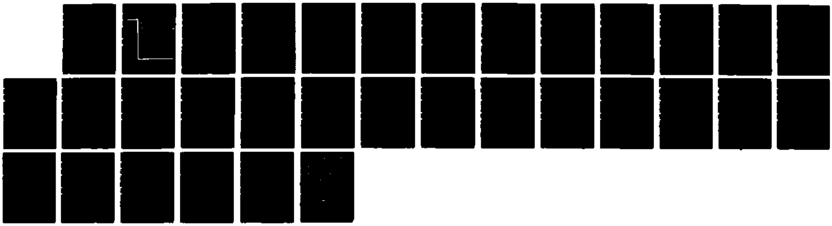

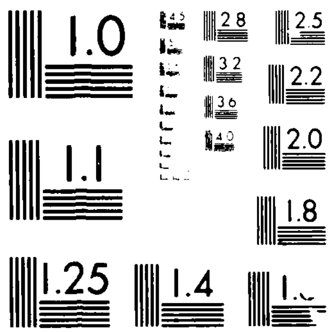

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PROCESSING AND CLASSIFICATION OF ENLISTEES (PACE) SYSTEM PAYOFF ALGORITHM DEVELOPMENT

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The Processing and Classification of Enlistees (PACE) is a post-enlistment system that classifies nonprior-service enlistees during Basic Military Training. The current system lacks flexibility and is driven largely by short-term priorities. Therefore, the system is being enhanced to be more responsive and easy to use. The enhancement involves the development of a mathemtical model called a payoff algorithm. The payoff algorithm uses information from personnel files and job files to generate a payoff (a numerical value) that indicates the worth to the Air Force of classifying a particular person into a particular job. The new PACE classification system will address management concerns (time, money, and fill priority) by classifying personnel more efficiently and address personnel concerns (aptitude, interests, and trainability) by classifying more effectively. Keywords: Policies.

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SUMMARY

In the United States Air Force (USAF), selection and classification of nonprior-service enlisted personnel are performed on two computer-based systems, the Procurement Management Information System (PROMIS) and the Processing and Classification of Enlistees (PACE) system. PROMIS is a pre-enlistment selection and classification system managed by USAF Recruiting Service, whereas PACE is a post-enlistment system managed by Headquarters Air Training Command (HQ ATC). The two systems annually select and classify approximately 56,000 nonprior-service enlisted personnel into one of nearly 300 Air Force specialties (AFSs).

The current PACE system has certain characteristics which limit its usefulness as a classification tool. Therefore, the system is being enhanced to improve its flexibility, efficiency, and effectiveness. The purpose of the enhancement is to design a system that reflects Air Force classification policy, optimally classifies personnel based on that policy, and is responsive and easy to use. This paper explains how the current PACE system operates and details the development and testing of the payoff algorithm for the new PACE system.

The payoff algorithm is a mathematical model that generates a numerical value (called a payoff) that indicates the worth to the Air Force of classifying a particular person into a particular AFS. The algorithm uses information about the individual and the AFS to generate a payoff.

The payoff algorithm will address both efficiency and effectiveness. Efficient classifications should improve manning in critical skills, reduce the waiting time between Basic Military Training (BMT) graduation and technical school entry (and associated costs), and increase the return on training dollar investment. Effective classifications should more closely match the aptitude of the person to the difficulty of the job and consider individual talents and interests in the classification process. The implementation of this algorithm will make possible the optimal classification of Air Force enlisted personnel in a more efficient and effective manner.

PREFACE

This technical paper documents research and development performed in response to Request for Personnel Research (RPR) 85-01, Expansion of Person-Job Match Technology, submitted by the Air Force Recruiting Service (AFRS), the Air Training Command (ATC), and the Air Force Military Personnel Center (AFMPC). Work was accomplished under work unit 77192009, Air Force Manpower and Personnel Modeling Research for Air Force Acquisition and Distribution.

The authors are indebted to Mr. Charles Rogers and Sgt Kevin Kumba (AFHRL/TSOZ) for their technical support in developing and maintaining software essential in the policy-specifying process used in the development of the new Processing and Classification of Enlistees (PACE) classification algorithm. In developing the algorithm, the authors received useful inputs and assistance from numerous individuals at AFHRL. Dr. William Alley, Mr. Larry Looper, Lt Col Robert Rue, SSgt Arthur Soria, Mr. John Taylor, Dr. Lonnie Valentine (AFHRL/MO), Dr. Joe Weeks (AFHRL/XO), and Ms. Doris Black (AFHRL/TSO) made valuable contributions to the effort.

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I. INTRODUCTION

In the United States Air Force (USAF), selection and classification of nonprior-service enlisted personnel are performed on two computer-based systems, the Procurement Management Information System (PROMIS) and the Processing and Classification of Enlistees (PACE) system. PROMIS is a pre-enlistment personnel selection and classification system managed by USAF Recruiting Service, whereas PACE is a post-enlistment system managed by Headquarters Air Training Command (HQ ATC) and used to classify enlistees during Basic Military Training (BMT). The two systems annually classify approximately 56,000 nonprior-service enlisted personnel into one of nearly 300 Air Force specialties (AFSs). Figure 1 outlines the classification process.

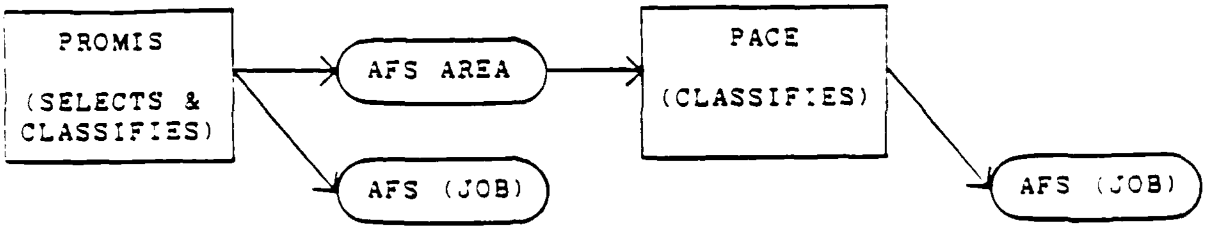

Figure 1. **PROMIS/PACE Classification Process.**

PROMIS processes nonprior-service recruits from the time of their application to the Air Force to the time they enter BMT (Hendrix, Ward, Pina, & Haney, 1979). To maintain flexibility in the classification process, PROMIS classifies approximately 50% of the recruits into specific AFSs through the Guaranteed Training Enlistment Program (GTEP) and the remaining recruits into one of four AFS areas: Mechanical (M), Administrative (A), General (G), or Electronics (E). Those classified into an AFS area are called Aptitude Index (AI) enlistments. Flexibility is necessary because some individuals become disqualified for the Air Force or their AFS, decide not to enlist, or do not graduate from BMT. Flexibility is also needed to accommodate last-minute changes in class schedules.

During BMT at Lackland AFB, Texas, the AI enlistees are classified by the PACE system into specific AFSs within their enlistment aptitude area. Personnel who enlist with a specific AFS under the GTEP are screened by the PACE system to ensure they are still qualified for their AFS. The PACE system then assigns each individual to a directed duty assignment (for on-the-job training) or to a technical training school.

The new PACE classification system will optimally classify trainees based on numerical values called "payoffs." A payoff value is calculated for each individual, indicating the worth to the Air Force of classifying that individual into a particular AFS. This paper describes the development of the payoff algorithm needed by the new PACE classification system.

The ability to generate a payoff for each AFS for which a person is eligible provides a basis for the optimization of classifications such that:

1. if payoff A is greater than payoff B, then the AFS position having payoff A is the better classification; and

2. if several trainees are classified into a set of AFS positions having the sum of payoffs S1, and if the same group is classified into a set of AFS positions having the sum of payoffs S2, with S1 greater than S2, then the set of AFS positions having the sum of payoffs S1 is the better set of classifications.

A description of the current system is necessary for a full appreciation of what is being done for the PACE system.

II. CURRENT PACE SYSTEM

PACE classification is a batch (as opposed to a sequential) process which makes classifications using a group of people and jobs. PACE is normally run once a week for all trainees in their 12th through 16th day of training (DOT). Such groups of airmen are called "week groups." To classify personnel, the PACE system uses input data from three files: a trainee file, a quota file, and an AFS prerequisite file.

Input Data Files

The trainee file contains personnel data such as gender, physical profile, courses taken, Air Force test scores, security data, and education level. The data are reviewed by the trainees on the 6th DOT, at which time their job preferences are added to the file.

The quota file contains training program requirements for each AFS for the week group. It shows how many airmen of each gender are needed for each technical training class, or directed duty assignment, to meet Air Force needs. It also contains a priority assigned by HQ ATC that indicates the order in which AFS requirements are to be filled (priority 1 AFSs are filled first; priority 9 AFSs are filled last).

The AFS prerequisite file is jointly maintained in PACE by the 3507th Airman Classification Squadron and Air Training Command (HQ ATC/TTPRS) and is based on Air Force Regulation (AFR) 39-1. The file contains prerequisite requirements for each AFS, such as completion of certain high school courses, color vision, required physical attributes, required test scores, etc. Trainees must meet an AFS's prerequisite requirements before being considered for that AFS.

The trainee and quota data for a particular week group are extracted from PACE and put on a tape file. The tape is used as input for the classification programs, which also use the AFS prerequisite file.

The trainee file, quota file, and AFS prerequisite file are combined into two files: a requirement file and a resource file. The requirement file contains only those portions of the quota file and AFS prerequisite file that pertain to the AFSs that will be available to individuals in the week group. The resource file contains personnel data for all trainees in the week group. The requirement and resource files are then combined to form a qualification file. Figure 2 shows the file sequence that is used for the current PACE system.

The qualification file identifies for each trainee in the week group all the AFSs for which the trainee qualifies. This is done by randomly assigning numbers to each trainee's records and each available AFS. Every AFS is then checked against each trainee's record to identify all AFSs for which the trainee qualifies. Every match is recorded by the number assigned to the individual and the number assigned to the AFS. After all matches are recorded, the classification process begins.

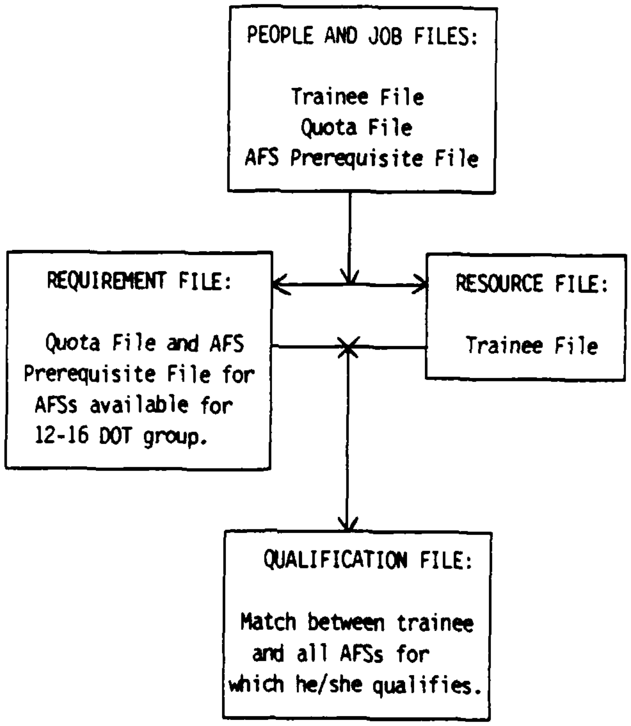

Figure 2. **File Sequence Under Current PACE System.**

In the current PACE classification system, decisions are made using a simplistic, non-optimal process, as shown in Figure 3.

Sort Sequence:	Order of Classification Within Sort:
Female	Guaranteed AFS Assignments
Volunteer Status	Priority 1,2 AFSs, Volunteers
AFS Match	Priority 1,2 AFSs, Nonvolunteers
ASVAB Score	Priority 3-7 AFSs, Volunteers
Desirables Missed	Priority 3-7 AFSs, Nonvolunteers
	Priority 8, 9 AFSs, Volunteers
Male	Priority 8, 9 AFSs, Nonvolunteers
Volunteer Status	
AFS Match	
ASVAB Score	
Desirables Missed	

Figure 3. **Current PACE Classification Process.**

Explanation of the Sort Sequence

On the 4th DOT, all AI trainees are given a list of available AFSs in their aptitude area, and a handout of AFS descriptions. They are asked to rank from 1 through 5 the five AFSs they consider most desirable. If a trainee chooses AFSs that require special testing or screening, he/she will be asked to select up to three additional AFSs in order to ensure that five valid preferences will be available for classification. On the 6th DOT, each trainee is interviewed by a classification expert. One responsibility of the interviewer is to eliminate from among the AFSs that the trainee has chosen those for which the trainee does not qualify. The remaining AFSs, but not more than five, are put into the computer. Volunteer status is indicated when the trainee has ranked an AFS with 1 through 5; a value of 9 indicates that the AFS was not one of the trainee's choices. Higher preferences (lower numbers) receive priority.

The AFS match indicates the degree to which the specialty matches the trainee's preference. Some specialties use a shredout identifier along with the basic five-digit Air Force Specialty Code (AFSC) to identify specific equipment items or aircraft. Thus, a trainee who indicates a preference for AFSC 43131A (A-7 aircraft maintenance) would have a five-digit match with AFSC 43131B (A-10 aircraft maintenance) but a six-digit match with AFSC 43131A. Six-digit matches receive priority over five-digit matches.

The ASVAB score is the trainee's composite score in a particular AI area (M, A, G, or E) from the Armed Services Vocational Aptitude Battery (ASVAB) (Ree, Welsh, Wegner, & Earles, 1985) taken at recruiting time. The test score gives an indication of the trainee's aptitude for the job. Higher scores receive priority.

Some AFSs have prerequisites that are desirable but not mandatory. These are based on feedback from technical training instructors as to what qualifications are likely to result in successful completion of the training. These "desirables" are also contained in AFR 39-1, and may include specifics related to physical profile, high school courses, test scores, etc. The desirables missed category refers to the number of desirables for the AFS that the trainee does not have. A lower number (i.e., less desirables missed) receives priority. However, this category is so far down in the sort sequence that it seldom enters the classification process.

Female trainees are sorted first because females can fill only female quotas, whereas males can fill either type of quota. (For example, females cannot fill combat-related AFSs.) The sequence is then repeated for male trainees.

Explanation of the Order of Classification Within Sort

Guaranteed AFS assignments are examined first. These include the recruits that were guaranteed an AFS (through GTEP) at recruiting time, plus the trainees that volunteered for a hard-to-fill AFS during BMT.

The priority given an AFS changes weekly and is determined by HQ ATC. Generally, priorities 1 and 2 mean the AFS must be filled first. These high priorities may have been assigned because there were unfilled technical training class seats from previous weeks, because the AFS is hard to fill, or because the technical training class for the AFS meets infrequently. Priorities 3 through 7 are filled next and are based on the trainee's preferences and qualifications. Priorities 8 and 9 represent future technical training classes that should be filled only after all others have been filled. Volunteers for an AFS are those who selected the AFS as one of their five choices; and nonvolunteers are those who did not include the AFS as one of their choices. Trainees receive their assignments on the 28th DOT.

Limitations

The current PACE system assigns approximately 97% of the trainees to an AFS; approximately 3% must be matched manually. Of those classified by PACE, about 75% get one of their first five choices. However, the PACE system, as it currently exists, does not optimize the person job match (PJM) process and is driven largely by short-term priorities. The potential and background of trainees receive little consideration. Also, once a trainee is matched to an AFS within PACE, that trainee is not considered for any other AFS. Under the present system, highly qualified trainees may be assigned to low-skill jobs, sometimes leaving only the less-qualified trainees for the more difficult jobs. Finally, the current system is not very flexible--it is difficult to add new classification factors, and the system does not reflect changes in the recruiting market.

III. PAYOFF ALGORITHM DEVELOPMENT

Basic Approach

The current PACE system is being enhanced to improve its flexibility, efficiency, and effectiveness. The purpose of this enhancement is to design a system that reflects Air Force classification policy, optimally classifies personnel based on that policy, and is responsive and easy to use.

So far, the enhancement has focused on the specification of a payoff algorithm and the testing of that algorithm. The payoff algorithm is a mathematical model that uses information about the individual and the AFS to generate a payoff.

The payoff algorithm is the key to the new PACE system. Therefore, it was carefully developed to consider all pertinent classification information. The payoff generated by the algorithm represents the worth to the Air Force of a particular classification action.

The payoff algorithm for PACE was developed over a 4-month period (September--December 1985), using an approach created at the Air Force Human Resources Laboratory (AFHRL) called policy specifying (Ward, 1977). Policy-specifying is a decision-modeling technique by which variables identified as pertinent to a decision-making process can be combined to derive a single payoff value. This technique was used for three reasons: (a) It was used successfully for developing the payoff algorithm for PROMIS in the 1970s, (b) it did not necessitate extensive data analysis (i.e., only it required two or three individuals who were knowledgeable of the classification system), and (c) it provided a means for deriving a payoff value where the criterion for matching a person to a job was not readily obvious.

The first step in the policy-specification process was to assemble a small team of classification experts and policy makers who could represent the Air Force in defining a policy for post-enlistment nonprior-service airman classification. The primary offices represented were the Training Programs Directorate and the Training Plans, Research and Technology Directorate (HQ ATC/TTP and /TTX) under the Deputy Chief of Staff for Technical Training (HQ ATC/TT). The team was advised and guided by task scientists from AFHRL. The Data Systems Support Division (HQ ATC/TTXD), as well as the Classification and Training Branch under the Director of Assignments at the Air Force Military Personnel Center (HQ AFMPC/DPMRTC), did not participate in the policy specification process; however, they were kept apprised of the team's work.

The team set two basic ground rules prior to beginning the policy-specification process. The first was to pattern the post-enlistment payoff algorithm for PACE along the same lines as the pre-enlistment payoff algorithm used in PROMIS. Although the two classification environments are somewhat different and have differing goals and objectives, similar factors should be used in both systems in order to maintain consistency. The second rule was to limit the selection of input variables to those currently (or soon to be) available in the various data systems and records used by classifiers, or to data that could be easily generated using other available sources or techniques. This rule was applied to increase the likelihood of implementation of the new system in the near future, without lengthy delays awaiting additional research.

The policy-specification team then began a series of weekly meetings to logically structure a mathematical model of the classification decision-making process. The first step was to gradually reduce the post-enlistment PJM problem to its most fundamental components. This initial top-down analysis dealt only with "fuzzy concepts," not specific, quantifiable variables. The conceptual taxonomy resulting from this analysis is shown in Figure 4 and discussed below.

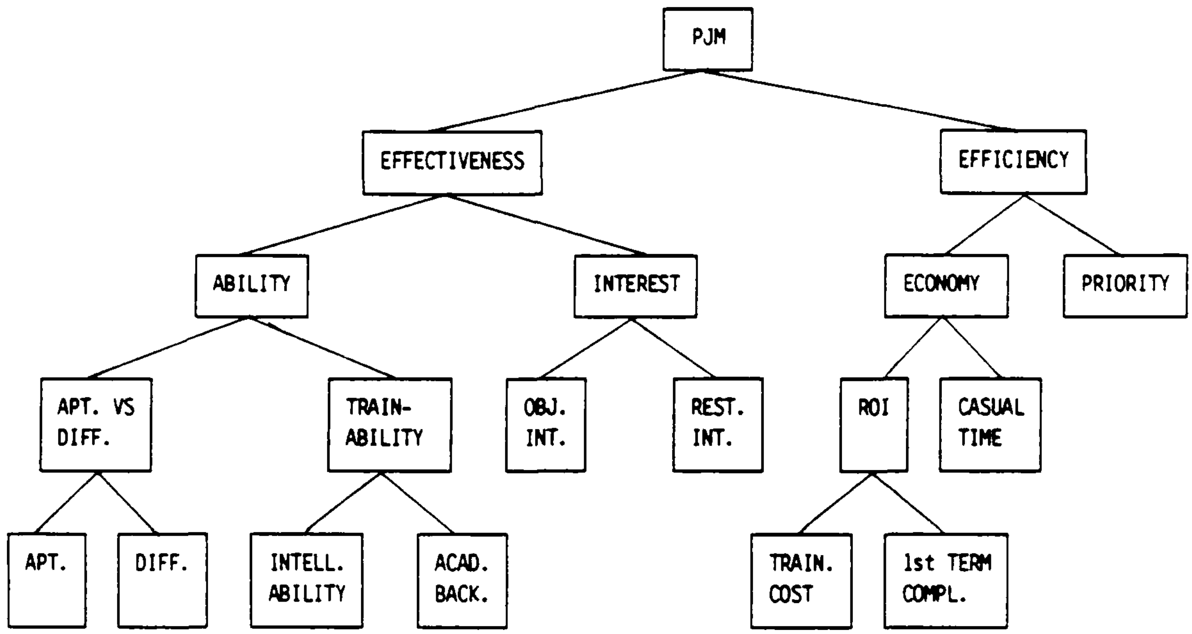

Figure 4. **Conceptual Taxonomy.**

The team felt that the first-level breakout of the PJM problem involved two (often competing) issues: efficiency (time, money, fill priority, etc.), to meet the short-term needs of the training system, versus effectiveness (aptitude, interest, trainability, etc.), to meet the longer-term goals of performance, retention, and readiness.

At the second level, the team felt that efficiency in classification could be subdivided into filling the highest-priority class seats and filling them in an economical manner (getting a good return on each training dollar invested, with a minimum of casual or standby time), whereas effectiveness in classification could be subdivided into the areas of ability to do a particular job and interest in doing that job.

At the next level, priority was not broken down further. However, the concept of job-fill economy was further reduced to two components: return on investment and the amount of casual time between graduation from BMT and entry into technical training. Ability was also divided into two component parts: aptitude versus difficulty and trainability (probability of successfully completing technical school). Interest also was subdivided into two components: objective interest (a relative measure of how well the job meets the individual's desires compared to all jobs) and restricted interest (how well the job satisfies the individual's desires compared to the other jobs available in the classification run).

At the lowest level, the aptitude versus difficulty measure was logically subdivided into aptitude and difficulty. At this point, the team felt that all but two of the "fuzzy concepts" had been reduced to their most fundamental levels. Trainability was thus further subdivided as intellectual ability and academic background, both of which are vital to successful completion of training. Finally, the concept of return on investment was subdivided into training cost and first-term completion (i.e., probability of completing the first enlistment).

Once the PJM decision-making process had been fully specified in general conceptual terms, the next task was to identify the best available data to represent each of the 10 fundamental concepts. Because this step required a transition from the theoretical to the practical, it naturally entailed many approximations and estimates.

The payoff algorithm and the variables that were selected to represent the 10 fundamental concepts are shown in Appendix A, and are described in detail below.

PACE Variables

X1. Aptitude. Aptitude for the job is the individual's M, A, G, or E aptitude index (AI) scores derived from his/her ASVAB scores. For each AFS, there is an associated minimum aptitude index requirement for entry; that is, a minimum acceptable score in one or more of the aptitude areas relevant to the AFS. The individual's AI score is compared against an AFS's minimum aptitude requirement to generate the payoff in assigning the individual to that AFS.

X2. Difficulty. Job difficulty measures were developed based on task analysis research results (Weeks, 1984). These measures provide an index to the relative difficulty of AFS on a scale equivalent to ASVAB scores. Since AFSs having the same required entry-level AI score are not necessarily of equal difficulty, the job difficulty measure is used to differentiate among them. Furthermore, the job difficulty measures are scaled such that valid comparisons can be made among AFSs whose entry-level requirements differ in terms of both aptitude areas and scores.

X3. Intellectual Ability. Intellectual ability is the predicted technical school grade from the 10 ASVAB subtest scores. Each AFS has a regression equation that uses ASVAB subtest scores to predict the technical school grade for the individuals being considered for classification into that AFS. These equations, developed through research, serve as a surrogate measure for prediction of future job performance (Wilbourn, Valentine, & Ree, 1984).

X4. Academic Background. Academic background is the percentage of completed desirable high school courses. For many AFSs, certain high school courses are deemed desirable (recommended but not required) for entry into the technical school. The academic background variable represents the percentage of these desirable courses an individual has taken. If the AFS has no desirable courses identified, each individual is assigned a score of 100% on this variable.

X5. Objective Interest. Objective interest is based on the Vocational Interest-Career Examination (VOICE) inventory, taken by the individuals who are being classified. The VOICE results are used to identify an individual's relative interest in the AFS compared to all AFSs (Alley, 1978).

X6. Restricted Interest. Restricted interest is based on the rank order of the five AFSs each individual chose and ranked during BMT.

X7. Training Cost. Training cost is the HQ ATC-specified cost (in thousands of dollars) of training an individual for a particular AFS. The cost values come from ATC cost factor documents. A value of 50 indicates that the cost of training is $50,000 or greater.

X8. First-Term Completion. The probability of completing the first term of enlistment is the likelihood of completion of at least 3 years of service in a particular AFS. Each AFS will have a regression equation to predict an individual's probability of retention. Personnel characteristics including age, sex, marital status, educational background, and aptitude scores are used as the independent variables (Finstuen & Alley, 1983).

X9. Casual Time. Casual time is the number of days between BMT graduation and technical school entry. Time spent in casual status is considered nonproductive and, therefore, not desirable.

X10. Priority. The fill priority for each AFS is assigned by HQ ATC at the time of classification. The priority values range from 1 to 10, with 1 being the highest priority.

X11. Effectiveness Weight. The weight assigned to the effectiveness side of the payoff algorithm determines whether greater emphasis is placed on the effectiveness (personnel) variables or efficiency (management) variables. The weight given to effectiveness affects efficiency, in that the efficiency weight is 100 minus the effectiveness weight. Increasing the weight on effectiveness will decrease the influence of management variables, and vice versa.

For these 11 variables, only the data for intellectual ability (X3) are not currently available. The research for this variable is complete, and the regression equations using the 10 ASVAB subtest scores are available; however, input data will not be available to PACE until these equations are implemented by PROMIS. Until they are implemented, PACE will use regression equations based on the four ASVAB AI scores.

The final step in developing the payoff algorithm was for the team to start at the lowest level of the conceptual taxonomy (shown in Figure 4) and work toward the top, substituting the variables identified above for the "fuzzy concepts." Each step of the process involved combining the variables pairwise into mathematical functions that would produce payoff values in the range of 0 to 100, where 100 represents the "best" combination of two variables and 0 represents the "worst." At the higher levels within the structure, the pairing occurs between functions, rather than variables. The final pairing, between efficiency and effectiveness, was left as a simple linear combination, with their relative weights to be assigned by management at run time. Detailed descriptions of each of the functions are contained below and in Appendix B.

PACE Functions

F1, F2, F3. Aptitude Versus Difficulty. The aptitude variable (X1) and the difficulty variable (X2) are paired in two ways (functions F1 and F2) to obtain the desired aptitude versus job difficulty relationship. The overall aptitude versus difficulty relationship, function F3, is the combination of functions F1 and F2. The classification policy makers felt that the highest function payoff should occur when the person's aptitude score matches the job difficulty score and should drop off as the two scores separate in either direction. This procedure decreases the likelihood of high aptitude individuals being classified into less difficult jobs and low aptitude individuals being assigned the more difficult jobs. The policy makers also agreed that the function payoff should decrease twice as much for those aptitude scores which are lower than the job difficulty score than for those which are higher. In fact, a negative function payoff occurs for individuals whose aptitude scores are more than 50 points lower than the job difficulty score.

F4. Trainability. The trainability function gives an indication of how easily a person can be trained for a particular AFS. This function is obtained by pairing the intellectual ability variable (X3) with the academic background variable (X4). The highest function payoff occurs when the scores for the two variables are each at their highest; the lowest payoff occurs when the scores are both at their lowest. The policy makers felt that intellectual ability is a more reliable indicator of trainability than is academic background; therefore, intellectual ability was given more weight in the function payoff.

F5. Ability. The ability function is an interaction between the aptitude versus difficulty function (F3) and the trainability function (F4). It gives an indication of how well a person might perform in a particular AFS. The highest function payoff occurs when scores for F3 and F4 are at their highest; the lowest function payoff occurs when these scores are at their lowest. The policy makers felt that the aptitude versus difficulty function (F3) was the more powerful indicator of ability; therefore, it was given greater weight in the function payoff.

F6. Interest. The interest function pairs the objective interest variable (X5) with the restricted interest variable (X6). This function gives an overall indication of the strength of an individual's interest in an AFS. As for the two previous functions, the highest function payoff occurs when each of the variables is at its highest; the lowest payoff, when the variables are at their lowest. In this case, both variables are assigned equal weights in the interest function (F6) payoff.

F7. Effectiveness. The effectiveness function is a combination of the ability function (F5) and the interest function (F6). This function is set up much like the trainability function (F4). Here the ability function is considered the more precise indicator of how effective an individual will be in a particular AFS.

This completes the description of the effectiveness side of the algorithm.

F8. Return on Investment. The return on investment function combines the first-term completion variable (X8) with the training cost variable (X7). This function attempts to match AFSs that have high training costs and individuals who indicate high probabilities of completing their first term of enlistment in those AFSs, in order to maximize the payback of initial training cost.

F9. Economy. The return on investment function (F8) paired with the casual time variable (X9) produces the job-fill economy function. The primary objective of this function is to minimize the cost of operating the initial skill training pipeline by increasing the return on training investment and by reducing the amount of casual time in the system.

F10. Efficiency. Finally, the efficiency function combines the economy function (F9) with the priority variable (X10). This function emphasizes the filling of high-priority jobs, and maximizes economic payoffs insofar as possible. The primary objective is to fill high-priority AFSs. Economy (i.e., filling AFSs with individuals having a high economic payoff) is a desired objective, of course, but necessarily of secondary importance.

F11, F12. Effectiveness Weight X Effectiveness and (100 - Effectiveness Weight) X Efficiency. When operating the payoff algorithm, management can adjust the effectiveness weight variable (X11) to emphasize either effectiveness of assignments (F11) or efficiency (F12). This gives management the flexibility to react to Air Force needs. When recruiting is good and there is little problem in filling AFSs, the effectiveness side can be emphasized. When fill becomes difficult, then the efficiency side must be emphasized. It is also possible to give the two sides equal weighting, if desired.

F13. Person Job Match. The final payoff value is obtained by combining the effectiveness function (F11) times its weighting with the efficiency function (F12) times its weighting. This result is the payoff to the Air Force of matching a particular individual to a particular AFS.

Payoff Algorithm Test Case

Upon completion of the payoff algorithm, a test was conducted using specially designed (simulated) personnel records. Each record contained the values of the input variables for a simulated person who was to be assigned to a specific AFS. The records were designed to cover the full range of values for the 10 input variables (X1 through X10), emphasizing the high and low extremes of the variables. The test was designed to ensure that a full range of the person job match function (F13) was being computed and that the final payoff values generated could be used to sort the records in proper sequence. When sorted in descending order by final payoff, the records should be ordered such that the best case has highest final payoff and the worst case has the lowest final payoff. The effectiveness weight variable (X11) on all the records was set at 50% to give equal weight to the effectiveness and efficiency sides of the payoff algorithm. Appendix C lists the eight records generated for testing, and the statistical results.

Table 1 provides a summary of the test records and their final payoffs. With the exception of the Priority variable (X10), HIGH indicates a high numerical value for the variable(s) and LOW indicates a low numerical value for the variable(s). Results from the test showed a wide range of final payoff values (13.1 to 80.9) and acceptable ordering of the records when sorted by final payoff.

Table 1. Change in Final Payoff by Variable(s)

Record number	Variable(s) changed	Status of variable(s) before change	Status of variable(s) after change	Final payoff
1	All variables near best value		BEST CASE	80.9
2	Return on Investment (X7, X8)	HIGH	LOW	78.4
3	Casual Time (X9)	LOW	HIGH	74.5
4	Interest in Job (X5, X6)	HIGH	LOW	70.4
5	Trainability (X3, X4)	HIGH	LOW	69.0
6	Aptitude vs Difficulty (X1, X2)	HIGH	LOW	60.7
7	Fill Priority (X10)	HIGH	LOW	54.2
8	All variables near worst value		WORST CASE	13.1

The first record was the best case, with all 10 input variables near their highest possible values; i.e., values that should contribute to achieving a high final payoff. This record resulted in the highest final payoff, which was 80.9. Records 2 through 7 each had one change in comparison to the first record. In each case, one function or variable value that contributed to achieving a high final payoff was changed to a function or variable value that would contribute to achieving a low final payoff. The final payoff order shows that the return on investment function (F8)--training cost variable (X7) paired with first-term completion variable (X8)--had the least effect on the final payoff. The priority variable (X10) had the greatest effect on final payoff. The eighth record was the worst case, with all 10 input variables near their lowest values; i.e., values that should contribute to achieving a low final payoff. This record gave the lowest final payoff, which was 13.1.

IV. NEW PACE CLASSIFICATION PROCESS

The new PACE system will operate like the current system, except for the actual classification process itself. Figure 5 illustrates the steps in the current PACE system that will be eliminated by using the new classification process. All the information needed for making classifications will be downloaded from ATC's Sperry 1100 mainframe computer to a Zenith 248 microcomputer. Once the microcomputer has computed the payoffs and determined the optimum assignments, the results will be uploaded to the Sperry 1100 mainframe for the continuation of the PACE process.

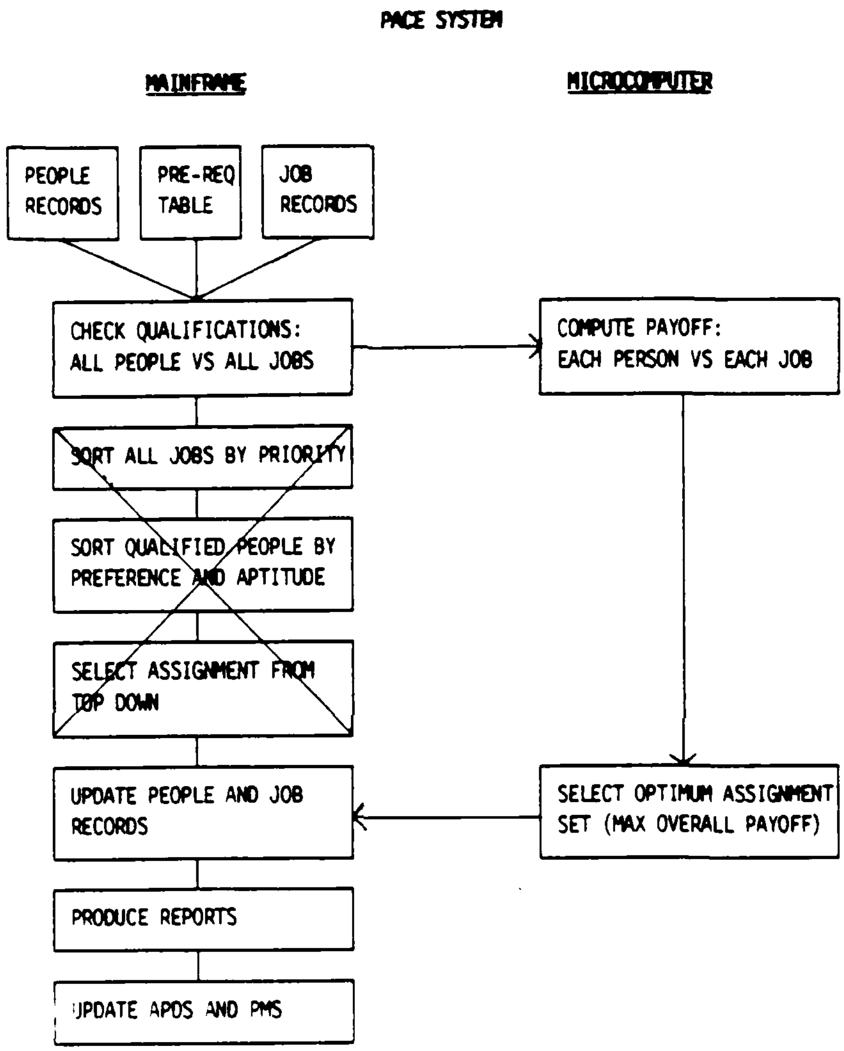

Figure 5. **PACE Classification Process.**

In order to classify personnel, the microcomputer will require the following inputs: (a) personnel requirements, (b) every AFS class for which each person is eligible, (c) personnel information needed by the payoff algorithm, (d) job variable information needed by the payoff algorithm, and (e) the payoff algorithm itself. Items (a) through (d) will be downloaded from the mainframe, and item (e) will be input from a separate file. The payoff algorithm will be maintained separately so that it can be changed when necessary. Classification can be accomplished by the microcomputer once all the data have been made available.

The classification system on the microcomputer will be divided into three modules and programmed as three sequentially executed programs, as shown in Figure 6. The first module will read all the information needed by the payoff algorithm, generate payoffs, and then arrange the information in a form needed by the next two modules.

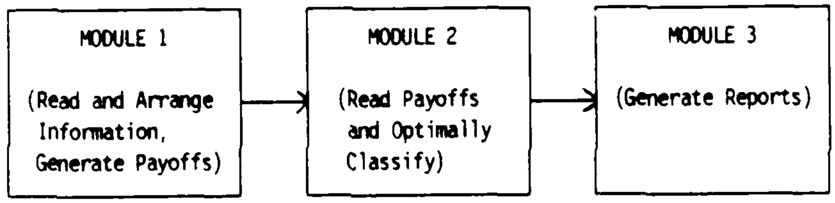

Figure 6. **Microcomputer Classification System.**

The second module will read the payoffs from the first module and optimally classify individuals within each week group via linear programming optimization techniques.

The third module will generate reports containing statistical information for classification evaluation purposes. The information from the third module will enable the user to determine whether the classification meets their requirements. If requirements are not being met, then the priority variable (X10) or the effectiveness weight variable (X11) can be adjusted in value until requirements are met. Once the user is satisfied, the results will be uploaded from the microcomputer to the mainframe computer. The mainframe computer will then complete the classification process as usual.

V. CONCLUSIONS

The development of a new post-enlistment payoff algorithm--which was the focus of this paper--was undertaken as part of an effort to enhance and upgrade the present PACE classification process. The enhancement will enable the Air Force to better classify personnel graduating from BMT, based on a policy defined by Air Force classification policy makers.

The PACE payoff algorithm addresses management's concern for the efficient classification of personnel. Efficient classification will: (a) improve manning in critical AFSs by controlling the fill priority to meet changing Air Force requirements, (b) minimize costs associated with casual time between BMT graduation and the technical school start date, and (c) maximize the payback from training by comparing the probability of attrition of each recruit in an AFS to the cost of training in that AFS.

The new PACE payoff algorithm also addresses management's interest in increasing job satisfaction, performance, and motivation. Effective classifications will address these objectives by better matching of the person's aptitude with the job's difficulty and by considering the person's talents and interests in the classification process. An effective classification should result in an "effective" enlisted member who is satisfied and motivated to perform well on the job.

The final product from the development of the PACE classification prototype will be a microcomputer-based classification system designed to respond to management's requirements. The enhancements to PACE will be the development of software for implementation of the payoff algorithm and mathematical techniques that will optimally classify personnel. These enhancements should enable the Air Force to efficiently, effectively, and optimally classify personnel. An added feature will be the capability to test the effects of changing particular variable values, to ensure that the final classification is the one that most closely meets personnel management requirements and results in the most effective utilization of Air Force personnel.

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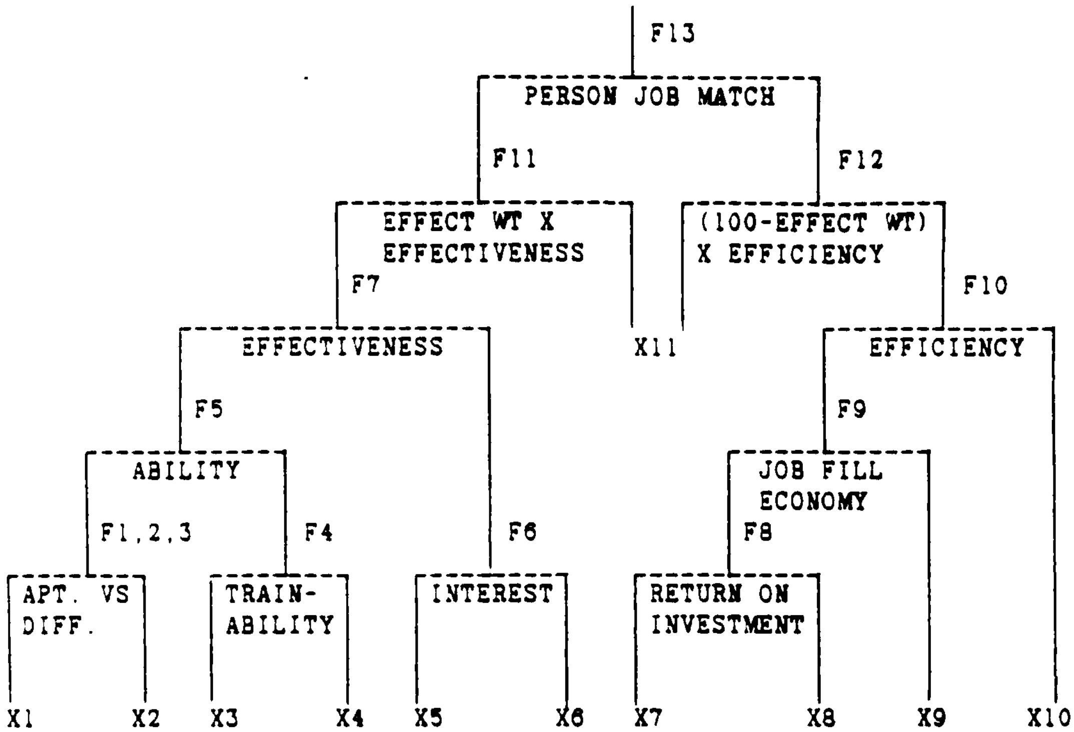
APPENDIX B: PACE PAYOFF ALGORITHM



X1. Aptitude for the Job - M, A, G, or E composite from ASVAB.

X2. Job (AFS) Difficulty - results from task analysis research done at AFHRL.

X3. Intellectual Ability - predicted technical school grade from ASVAB subtest scores.

X4. Academic Background - percentage of completed desirable high school courses.

X5. Objective Interest - VOICE score indicating relative interest in the AFS compared to all AFSs.

X6. Restricted Interest - individual's ranking of five AFSs available in his/her aptitude area.

X7. Training Cost - data from ATC cost factor documents.

X8. Probability of Completing First Term of Enlistment - based on regression equation predictions developed at AFHRL.

X9. Casual Time - number of days between basic training graduation and technical school entry.

X10. Fill Priority - priority assigned by HQ ATC at the time of classification.

X11. Effectiveness Weight - controls the emphasis to be placed on effectiveness.

FUNCTION NAMES

F01=F(X 1,X 2)	APTITUDE VS JOB DIFFICULTY
F02=F(X 1,X 2)	APTITUDE VS JOB DIFFICULTY
F03=F(F 1,F 2)	APTITUDE/JOB DIFFICULTY
F04=F(X 3,X 4)	TRAINABILITY
F05=F(F 3,F 4)	ABILITY
F06=F(X 5,X 6)	INTEREST
F07=F(F 5,F 6)	EFFECTIVENESS
F08=F(X 8,X 7)	RETURN ON INVESTMENT
F09=F(F 8,X 9)	JOB FILL ECONOMY
F10=F(F 9,X10)	EFFICIENCY
F11=F(F 7,X11)	EFFECT WT X EFFECTIVENESS
F12=F(F10,X11)	(100-EFFECT WT) X EFFICIENCY
F13=F(F11,F12)	PERSON JOB MATCH

APPENDIX B: FUNCTION PAYOFFS FOR SELECTED INPUT VALUES

F 1=F(X 1,X 2) MODEL 1 APTITUDE VS JOB DIFFICULTY
X 1=APTITUDE
X 2=JOB DIFFICULTY

F 1 X 2

		0	10	20	30	40	50	60	70	80	90	100
	100	0	10	20	30	40	50	60	70	80	90	100
	90	10	20	30	40	50	60	70	80	90	100	100
	80	20	30	40	50	60	70	80	90	100	100	100
	70	30	40	50	60	70	80	90	100	100	100	100
	60	40	50	60	70	80	90	100	100	100	100	100
X 1	50	50	60	70	80	90	100	100	100	100	100	100
	40	60	70	80	90	100	100	100	100	100	100	100
	30	70	80	90	100	100	100	100	100	100	100	100
	20	80	90	100	100	100	100	100	100	100	100	100
	10	90	100	100	100	100	100	100	100	100	100	100
	0	100	100	100	100	100	100	100	100	100	100	100

F 2=F(X 1,X 2) MODEL 1 APTITUDE VS JOB DIFFICULTY
X 1=APTITUDE
X 2=JOB DIFFICULTY

F 2 X 2

		0	10	20	30	40	50	60	70	80	90	100
	100	100	100	100	100	100	100	100	100	100	100	100
	90	100	100	100	100	100	100	100	100	100	100	80
	80	100	100	100	100	100	100	100	100	100	80	60
	70	100	100	100	100	100	100	100	100	80	60	40
	60	100	100	100	100	100	100	100	80	60	40	20
X 1	50	100	100	100	100	100	100	80	60	40	20	0
	40	100	100	100	100	100	80	60	40	20	0	-20
	30	100	100	100	100	80	60	40	20	0	-20	-40
	20	100	100	100	80	60	40	20	0	-20	-40	-60
	10	100	100	80	60	40	20	0	-20	-40	-60	-80
	0	100	80	60	40	20	0	-20	-40	-60	-80	-100

F 3=F(F 1,F 2) MODEL 1 APTITUDE/JOB DIFFICULTY
F 1=F(X 1,X 2) MODEL 1 APTITUDE VS JOB DIFFICULTY
F 2=F(X 1,X 2) MODEL 1 APTITUDE VS JOB DIFFICULTY

F 3 F 2

		-100	-80	-60	-40	-20	0	20	40	60	80	100
	100	-100	-80	-60	-40	-20	0	20	40	60	80	100
	90											90
	80											80
	70											70
	60											60
F 1	50											50
	40											40
	30											30
	20											20
	10											10
	0											0

F 4=F(X 3,X 4) MODEL 1 TRAINABILITY
X 3=INTELLECTUAL ABILITY
X 4=ACADEMIC BACKGROUND

F 4 X 4

		0	10	20	30	40	50	60	70	80	90	100
	100	80	82	84	86	88	90	92	94	96	98	100
	90	72	74	76	78	80	82	84	86	88	90	92
	80	64	66	68	70	72	74	76	78	80	82	84
	70	56	58	60	62	64	66	68	70	72	74	76
	60	48	50	52	54	56	58	60	62	64	66	68
X 3	50	40	42	44	46	48	50	52	54	56	58	60
	40	32	34	36	38	40	42	44	46	48	50	52
	30	24	26	28	30	32	34	36	38	40	42	44
	20	16	18	20	22	24	26	28	30	32	34	36
	10	8	10	12	14	16	18	20	22	24	26	28
	0	0	2	4	6	8	10	12	14	16	18	20

F 5=F(F 3,F 4) MODEL 1 ABILITY
F 3=F(F 1,F 2) MODEL 1 APTITUDE/JOB DIFFICULTY
F 4=F(X 3,X 4) MODEL 1 TRAINABILITY

F 5		F 4: 0	10	20	30	40	50	60	70	80	90	100
	100	50	55	60	65	70	75	80	85	90	95	100
	80	45	50	54	59	64	69	73	78	83	87	92
	60	40	44	49	53	58	62	66	71	75	80	84
	40	35	39	43	47	51	56	60	64	68	72	76
	20	30	34	38	41	45	49	53	57	60	64	68
F 3	0	25	29	32	36	39	43	46	50	53	57	60
	-20	20	23	26	30	33	36	39	42	46	49	52
	-40	15	18	21	24	27	30	32	35	38	41	44
	-60	10	13	15	18	20	23	25	28	31	33	36
	-80	5	7	10	12	14	17	19	21	23	26	28
	-100	0	2	4	6	8	10	12	14	16	18	20

F 6=F(X 5,X 6) MODEL 1 INTEREST
X 5=OBJECTIVE INTEREST
X 6=RESTRICTED INTEREST

F 6		X 6: 60	80	85	90	95	100
	100	80	100	100	100	100	100
	90	70	90	95	100	100	100
	80	60	80	85	90	95	100
	70	50	70	75	80	85	90
	60	40	60	65	70	75	80
X 5	50	30	50	55	60	65	70
	40	20	40	45	50	55	60
	30	10	30	35	40	45	50
	20	0	20	25	30	35	40
	10	0	10	15	20	25	30
	0	0	0	5	10	15	20

F 7=F(F 5,F 6) MODEL 1 EFFECTIVENESS
F 5=F(F 3,F 4) MODEL 1 ABILITY
F 6=F(X 5,X 6) MODEL 1 INTEREST

F 7		F 6										
		0	10	20	30	40	50	60	70	80	90	100
	100	70	73	76	79	82	85	88	91	94	97	100
	90	63	66	69	72	75	78	81	84	87	90	93
	80	56	59	62	65	68	71	74	77	80	83	86
	70	49	52	55	58	61	64	67	70	73	76	79
	60	42	45	48	51	54	57	60	63	66	69	72
F 5	50	35	38	41	44	47	50	53	56	59	62	65
	40	28	31	34	37	40	43	46	49	52	55	58
	30	21	24	27	30	33	36	39	42	45	48	51
	20	14	17	20	23	26	29	32	35	38	41	44
	10	7	10	13	16	19	22	25	28	31	34	37
	0	0	3	6	9	12	15	18	21	24	27	30

F 8=F(X 8,X 7) MODEL 1 RETURN ON INVESTMENT
X 8=PROB. OF COMP. TERM
X 7=TRAINING COST

F 8		X 7										
		0	5	10	15	20	25	30	35	40	45	50
	100	0	19	36	51	64	75	84	91	96	99	100
	90	10	25	39	51	61	70	77	83	87	89	90
	80	20	31	42	51	58	65	70	75	78	79	80
	70	30	38	44	50	56	60	64	66	68	70	70
	60	40	44	47	50	53	55	57	58	59	60	60
X 8	50	50	50	50	50	50	50	50	50	50	50	50
	40	60	56	53	50	47	45	43	42	41	40	40
	30	70	62	56	50	44	40	36	34	32	30	30
	20	80	69	58	49	42	35	30	25	22	21	20
	10	90	75	61	49	39	30	23	17	13	11	10
	0	100	81	64	49	36	25	16	9	4	1	0

F 9=F(F 8,X 9) MODEL 1 JOB FILL ECONOMY
F 8=F(X 8,X 7) MODEL 1 RETURN ON INVESTMENT
X 9=CASUAL TIME

F 9 X 9

		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	100	100	100	99	97	94	91	87	83	77	71	64	57	49	40	30	20
	90	95	95	94	92	90	86	83	78	73	67	61	54	46	37	28	18
	80	90	90	89	87	85	82	78	74	69	63	57	50	43	34	26	16
	70	85	85	84	82	80	77	74	70	65	59	53	47	40	32	23	14
	60	80	80	79	77	75	72	69	65	61	56	50	43	36	29	21	12
F 8	50	75	75	74	72	70	68	65	61	57	52	46	40	33	26	18	10
	40	70	70	69	68	66	63	60	56	52	48	42	37	30	23	16	8
	30	65	65	64	63	61	58	56	52	48	44	39	33	27	21	14	6
	20	60	60	59	58	56	54	51	48	44	40	35	30	24	18	11	4
	10	55	55	54	53	51	49	47	43	40	36	31	26	21	15	9	2
	0	50	50	49	48	46	44	42	39	36	32	28	23	18	12	6	0

F10=F(F 9,X10) MODEL 1 EFFICIENCY
F 9=F(F 8,X 9) MODEL 1 JOB FILL ECONOMY
X10=FILL PRIORITY

F10 X10

		1	2	3	4	5	6	7	8	9	10
	100	100	75	58	44	34	27	23	21	20	20
	90	95	72	54	41	31	25	21	19	18	18
	80	90	68	51	38	29	22	19	17	16	16
	70	85	64	47	35	26	20	17	15	14	14
	60	80	60	44	32	24	18	15	13	12	12
F 9	50	75	56	41	29	21	16	12	11	10	10
	40	70	52	37	26	19	13	10	9	8	8
	30	65	47	34	23	16	11	8	7	6	6
	20	60	43	30	21	14	9	6	5	4	4
	10	55	39	27	18	11	7	4	3	2	2
	0	50	35	24	15	9	4	2	1	0	0

F11=F(F 7,X11) MODEL 1   EFFECT WT X EFFECTIVENESS
F 7=F(F 5,F 6) MODEL 1   EFFECTIVENESS
X11=EFFECTIVENESS WEIGHT

F11 (rows: F 7; columns: X11)

F 7	0	10	20	30	40	50	60	70	80	90	100
100	0	100	200	300	400	500	600	700	800	900	1000
90	0	90	180	270	360	450	540	630	720	810	900
80	0	80	160	240	320	400	480	560	640	720	800
70	0	70	140	210	280	350	420	490	560	630	700
60	0	60	120	180	240	300	360	420	480	540	600
50	0	50	100	150	200	250	300	350	400	450	500
40	0	40	80	120	160	200	240	280	320	360	400
30	0	30	60	90	120	150	180	210	240	270	300
20	0	20	40	60	80	100	120	140	160	180	200
10	0	10	20	30	40	50	60	70	80	90	100
0	0	0	0	0	0	0	0	0	0	0	0

F12=F(F10,X11) MODEL 1   (100-EFFECT WT) X EFFICIENCY
F10=F(F 9,X10) MODEL 1   EFFICIENCY
X11=EFFECTIVENESS WEIGHT

F12 (rows: F10; columns: X11)

F10	0	10	20	30	40	50	60	70	80	90	100
100	1000	900	800	700	600	500	400	300	200	100	0
90	900	810	720	630	540	450	360	270	180	90	0
80	800	720	640	560	480	400	320	240	160	80	0
70	700	630	560	490	420	350	280	210	140	70	0
60	600	540	480	420	360	300	240	180	120	60	0
50	500	450	400	350	300	250	200	150	100	50	0
40	400	360	320	280	240	200	160	120	80	40	0
30	300	270	240	210	180	150	120	90	60	30	0
20	200	180	160	140	120	100	80	60	40	20	0
10	100	90	80	70	60	50	40	30	20	10	0
0	0	0	0	0	0	0	0	0	0	0	0

F13=F(F11,F12) MODEL 1 PERSON JOB MATCH
F11=F(F 7,X11) MODEL 1 EFFECT WT X EFFECTIVENESS
F12=F(F10,X11) MODEL 1 (100-EFFECT WT) X EFFICIENCY

F13		F12										
		0	100	200	300	400	500	600	700	800	900	1000
	1000	100	110	120	130	140	150	160	170	180	190	200
	900	90	100	110	120	130	140	150	160	170	180	190
	800	80	90	100	110	120	130	140	150	160	170	180
	700	70	80	90	100	110	120	130	140	150	160	170
	600	60	70	80	90	100	110	120	130	140	150	160
F11	500	50	60	70	80	90	100	110	120	130	140	150
	400	40	50	60	70	80	90	100	110	120	130	140
	300	30	40	50	60	70	80	90	100	110	120	130
	200	20	30	40	50	60	70	80	90	100	110	120
	100	10	20	30	40	50	60	70	80	90	100	110
	0	0	10	20	30	40	50	60	70	80	90	100

APPENDIX C: TEST VALUES AND STATISTICAL SUMMARY
VALUES FOR VARIABLES X1-X11 AND PAYOFFS FOR FUNCTIONS F1-F13

Record	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
1	80	70	90	90	80	90	40	80	2	2
2	80	70	90	90	80	90	10	40	2	2
3	80	70	90	90	80	90	40	80	10	2
4	80	70	90	90	40	60	40	80	2	2
5	80	70	20	20	80	90	40	80	2	2
6	20	100	90	90	80	90	40	80	2	2
7	80	70	90	90	80	90	40	80	2	9
8	20	100	20	20	40	60	10	40	10	9

Record	X11	F1	F2	F3	F4	F5	F6	F7	F8
1	50	90.0	100.0	90.0	90.0	91.1	90.0	90.8	77.6
2	50	90.0	100.0	90.0	90.0	91.1	90.0	90.8	52.8
3	50	90.0	100.0	90.0	90.0	91.1	90.0	90.8	77.6
4	50	90.0	100.0	90.0	90.0	91.1	20.0	69.8	77.6
5	50	90.0	100.0	90.0	20.0	57.2	90.0	67.0	77.6
6	50	100.0	-60.0	-60.0	90.0	33.4	90.0	50.4	77.6
7	50	90.0	100.0	90.0	90.0	91.1	90.0	90.8	77.6
8	50	100.0	-60.0	-60.0	20.0	15.2	20.0	16.6	52.8

Record	F9	F10	F11	F12	F13 (Final Payoff)
1	87.5	71.1	454.0	355.3	80.9
2	75.2	66.0	454.0	330.1	78.4
3	56.2	58.2	454.0	291.1	74.5
4	87.5	71.1	349.0	355.3	70.4
5	87.5	71.1	335.2	355.3	69.0
6	87.5	71.1	251.9	355.3	60.7
7	87.5	17.6	454.0	88.0	54.2
8	47.1	9.5	83.2	47.6	13.1

Statistical Summary of Records 1-8

Variable or Function	Lowest Value that Occurred	Highest Value that Occurred	Mean	Std Dev (N)	Std Dev (N-1)
X1	20.000	80.000	65.000	25.981	27.775
X2	70.000	100.000	77.500	12.990	13.887
X3	20.000	90.000	72.500	30.311	32.404
X4	20.000	90.000	72.500	30.311	32.404
X5	40.000	80.000	70.000	17.321	18.516
X6	60.000	90.000	82.500	12.990	13.887
X7	10.000	40.000	32.500	12.990	13.887
X8	40.000	80.000	70.000	17.321	18.516
X9	2.000	10.000	4.000	3.464	3.703
X10	2.000	9.000	3.750	3.031	3.240
X11	50.000	50.000	50.000	0.000	0.000
F1	90.000	100.000	92.500	4.330	4.629
F2	-60.000	100.000	60.000	69.282	74.066
F3	-60.000	90.000	52.500	64.952	69.437
F4	20.000	90.000	72.500	30.311	32.404
F5	15.200	91.150	70.194	29.032	31.036
F6	20.000	90.000	72.500	30.311	32.404
F7	16.640	90.805	70.886	24.915	26.636
F8	52.800	77.600	71.400	10.739	11.480
F9	47.138	87.497	77.011	15.318	16.376
F10	9.516	71.052	54.444	24.050	25.710
F11	83.200	454.025	354.428	124.576	133.178
F12	47.578	355.258	272.219	120.248	128.550
F13	13.078	80.928	62.665	20.485	21.899

END
DATE
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